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Development of a test blueprint for the National Association of Industrial Technology certification exam

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Development of a Test Blueprint for the National Association of Industrial Technology Certification Exam

by

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For the Major Program

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ABSTRACT

The primary purpose of this study was to develop a test blueprint that would serve to identify core content, subject areas, and competencies needed to update the NAIT Certification Exam. The original certification program was established by the National Association of Industrial Technology (NAIT) in 1991, and eight areas were identified: (1) Quality Control; (2) Production Planning and Control; (3) Industrial Supervision; (4) Industrial Finance and Accounting; (5) Industrial Safety; (6) Plant Layout and Material Handling; (7) Time And Motion Study; and (8) Industrial Communications. A prototype testing was conducted in an attempt to improve the reliability of the test, and in 1995 the Certification Committee recommended: (1) editing questions for clarification; (2) deleting 80 inappropriate questions; (3) adding approximately 40 new questions; and (4) collapse the exam into four content areas to increase test validity.

The problem addressed in this study is the need to determine if the earlier test development reflects current NAIT Certification Exam requirements. The current exam was developed ten years ago, and there has been a clear need to address rapid changes in technology and its uses. A modified Delphi technique was used to identify core content, subject areas, and competencies. Two Delphi Rounds were conducted in which 14 panelists identified 13 core competency areas: (1) Leadership Skills For Supervisors; (2) Teamwork; (3) Fundamentals of Management; (4) Safety Management; (5) Technical Graphics/CADD; (6) Quality; (7) Electronics; (8) Human Resource Management; (9) Technical Writing; (10) Written Communication; (11) Verbal Communication; (12) Computer Integrated Manufacturing and, (13) Manufacturing Automation.

The findings of the study also indicated a greater need for expanding the use of information, particularly in written and verbal communication, especially how to communicate technical information to others. This is in line with the current needs of a growing informational society that is characterized by rapid advances in technologies and the need for higher levels of knowledge required of those who will lead in a complex world. Industrial Technologists are at the forefront of this movement because of their unique blend of expertise in technology and management that is based on theory and application.

CHAPTER 1. INTRODUCTION

Background of the Study

Certification programs have existed in various professions and occupations since World War II. The National Certification Commission (NCA), the National Organization for Competency Assurance (NOCA), and the National Commission for Certification Agencies (NCCA) are certification associations that provide standards and guidelines for certification. The American Psychological Association (APA), American Education Research Association (AERA), and the National Council on Measurement in Education (NCME) provide standards for test development that certification associations typically use in certification testing. Table 1 lists the various organizations and agencies that provide standards for testing, certification, certification programs, and assessment services.

Table 1. Certification programs, test standards, certification standards, and assessment services agencies and organizations

Certification programs	Test standards	Certification standards	Assessment services
National Association of Industrial Technologists (NAIT)	American Psychological Association (APA)	National Occupational Competency Testing Institute (NOCTI)	National Organization for Competency Assurance (NOCA)
Certified Public Accountant (CPA)	American Education Research Association (AERA)	Chauncey Group	National Certification Commission (NCA)
Certified Manufacturing Engineer (SME)	National Council on Measurement in Education (NCME)		National Commission for Certification Agencies (NCCA)

Certification is defined as a voluntary process. A certification program provides assurances that an individual has met a pre-established set of qualifications in a profession or occupation based on requirements considered appropriate by its representative association (Jaffeson, 2001, January).

There are thousands of certification programs available in many different professions and occupations. Hamm (1996) lists 28 occupational categories for certification that include approximately 1,600 granting certificate programs and over 200 accrediting organizations. Despite the growing number of certification programs, there is a general lack of organization, accessibility, and consensus of information on certification programs (Tillman, 1995). However, NOCA, NCA, NCCA, Barnhardt's *Guide to national professional certification programs* (1994), and others help to give focus to the certification process. Professional certification helps both the individual and the organization (Barnhardt, 1994). Individuals are able to document their skills and knowledge within a given profession. Organizations are given some assurances that individuals are involved in professional development. In addition, the fact that an individual is certified may be the best indicator of how qualified is a potential or current employee (Pare, 1996).

Test Development

Test construction involves ten steps, including preparing a set of test specifications or a test blueprint. A test blueprint involves delineating the proportion of items that should define each domain of interest (Althouse, 2001; Crocker & Algina, 1986) as well as identifying the certification audience, deciding on the type of test, how to test, and developing psychometrically sound instruments and procedures and ensuring test validity (Fortune & Associates, 1985). In *Educational Measurement,* Thorndike (1971) defines the test blueprint as providing an effective guide for item writing.

Central to any discussion on test construction is ensuring that tests are psychometrically sound. At the test blueprint development stage, ensuring the validity of a test is one of the most important considerations (AERA, APA, & NCME, 1985; Cocker & Algina, 1986; Haladyna, 1999; Wiersma & Jurs, 1985). Additionally, ensuring the reliability of the decision of whether to certify is also of primary importance (AERA, APA, & NCME, 1985). The decision to certify was made by NAIT with the establishment of the Certification Association in 1991.

Validity refers to the appropriateness and usefulness of the specific inferences made from test scores (AERA, APA, & NCME, 1985). There are several methods to validate test content depending upon the purpose(s) of the test. In certification and licensing testing, the focus is on knowledge and skills. Because certification testing is directly involved in assessing skills and knowledge to perform a particular job, job and task analysis are recommended to validate certification test content (AERA, APA, & NCME, 1985; Haladyna, 1999). Job and task analysis are accomplished in a number of ways, however, expert judgment is described as the best way to achieve consensus among content experts and is a "critical piece of evidence to test score interpretation and item response validation" (Haladyna, 1999, p. 147).

After the test objectives and test content have been identified, instructional objectives or outcomes should be written that reflect the intended outcome of instruction or, for the purpose of certification, the intended outcomes for the examinee. Bloom' s *Taxonomy of educational objectives* (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956) outlines six major categories in the cognitive domain that are hierarchical with respect to the complexity of knowledge required to attain the test outcomes or objectives (Wiersma & Jurs, 1985). The *Taxonomy* provides a basis upon which to prepare a table of test specifications that describe how many items should represent each content domain proportionally. Bloom's six categories of cognitive behaviors are: (1) Knowledge; (2) Comprehension; (3) Application; (4) Analysis; (5) Synthesis; and (6) Evaluation.

Selecting the type of test is the next step in developing a certification test. The test developer may choose multiple-choice, computer adaptive testing, essay, or other test formats depending on the purposes, audience, and objectives of the test.

The NAIT Certification Program

The National Association of Industrial Technology (NAIT) established a certification program in 1991. The NAIT Certification Board coordinates and conducts all certification activity. In 1991, seven members comprised the committee that developed initial certification guidelines and procedures subsequently approved by the Certification Board. The original certification guidelines were intended to encourage NAIT graduates and certified individuals to continue professional development activities. The Certification Board decided to set up a NAIT certification examination program as a way to certify professionals who did not meet original certification criteria (Field, 1999).

There are two levels of NAIT certification that are currently available, the Certified Industrial Technologist (CIT) and the Certified Senior Industrial Technologist (CSIT). The

CIT is awarded to graduates and faculty of NAIT-accredited associate and baccalaureate Industrial Technology degree programs. The CSIT is awarded to graduates and faculty of NAIT-accredited associate and baccalaureate degree Industrial Technology programs with five years of professional experience and 75 hours of professional development units (Field, 1999). CSIT certification must be renewed every five years. The required professional experience may be earned by teaching at a NAIT-accredited Industrial Technology program or by having been employed as industrial technologists in business and industry. Additionally, a written examination is available for professionals who do not meet CIT or CSIT academic requirements. Since the beginning of the certification program, 1,572 individuals have been NAIT certified. A total of 484 of these individuals currently maintain active certification (Field, 1999). Table 2 lists the type of certification awarded in each year since 1992. In Phase I of the NAIT Certification exam development, the core content and subject areas were identified during a Delphi study. The core technical management areas for the accredited baccalaureate degree programs were identified in the Delphi study.

In Phase II, sample test items were written and assembled in a prototype form and administered to 60 examinees. As a result of the prototype testing and in an attempt to improve the reliability of the test, the Certification Committee recommended the following actions: (1) edit questions for clarification; (2) delete 80 inappropriate questions; (3) add approximately 40 new questions; and (4) collapse the exam into four content areas to increase test validity (Field, 1999).

Table 2. Number of Certified Industrial Technologist (CIT) and Certified Senior Industrial Technologist (CSIT) certifications awarded since 1992

Year of initial certification	CIT	CSIT
1992	44	104
1993	16	41
1994	11	12
1995	20	10
1996	13	2
1997	24	2
1998	31	5
1999	81	3
2000	61	4

(Field, 1999).

Problem of the Study

The problem addressed in this study is the need to determine if earlier test development reflects current requirements. The challenge to remedy the problem was to develop a test blueprint that identifies and updates test content for the NAIT Certification examination. NOCA & NCCA (2000) states that a certification program must establish periodic reviews of test content and performance domains. Because the current examination was developed ten years ago, it is indeed time for NAIT Certification to review its test content. Tillman (1989) cites the need for the Society of Manufacturing Engineers (SME) to update its certification examinations and attributes the need to do so to rapid changes in technology and its uses.

Purpose of the Study

The primary purpose of this study was to develop a test blueprint that serves to identify core content, subject areas, and competencies needed to update the NAIT Certification examination. Eight core content areas were identified in Phase I of the 1991 Delphi study: (1) Quality Control; (2) Production Planning and Control; (3) Industrial Supervision; (4) Industrial Finance and Accounting; (5) Industrial Safety; (6) Plant Layout and Material Handling; (7) Time and Motion Study; and (8) Industrial Communications. A modified Delphi technique was used again in this study to identify core content, subject areas, and competencies. The rationale for using the Delphi technique is that the technique relies upon expert judgment to validate test content. This study is a descriptive as well as developmental study that seeks to determine: (1) if there should be additions or subtractions to the core content list; and (2) if the core content and subject areas are different in 2001 than they were in 1991.

The researcher was concerned whether there has been a change in the core content areas originally identified for the NAIT Certification examination in 1991. Thus, a secondary purpose of this study was to identify if there were any perceived differences in the core content, subject areas, and competencies identified by representatives from NAIT-accredited institutions and practicing industrial technologists.

Significance and Need for the Study

NAIT certification provides assurances about an individual's knowledge, application, and continuing professional development and promotes awareness about the expertise and educational background of an industrial technologist (Field, 1999). It follows that the NAIT

Certification examination should be updated periodically in order to align academic programs with business and industry needs.

NAIT accreditation was established in part to standardize the Industrial Technology curriculum so that employers would have a clear understanding about the qualifications of Industrial Technology graduates. The standards of accreditation for the baccalaureate degree program include major course work in general education such as the humanities, English, history, economics and the physical sciences. The major core requirements include courses in management, and in technical areas including quality control, production planning, computer-aided manufacturing, electronics, computer-aided design and other technical subjects (NAIT, 2000).

This study assesses the core content and subject areas to promote a clear understanding of industrial technology graduates' qualifications and to align industrial technology graduates' academic experiences with practicing industrial technology professionals. This study focuses on the best practices for certification test blueprint development based on standards developed by NCCA, NOCA, NCCA, and other certification agencies and associations.

Research Questions

The challenge was to identify the core content areas for the NAIT Certification examination. The following research questions addressed this challenge:

1. What are the core content, subject areas, and related competencies that NAIT-accredited institutions and practicing industrial technologists recommend for the NAIT Certification examination?

2. Do the core content, subject areas, and related competencies identified by NAIT-accredited schools differ from what practicing industrial technologists view as the knowledge, skills and related competencies required for entry-level industrial technologists?
3. What is the percentage of items that should be represented by each of the six domains as outlined in Bloom et al. (1956) *Taxonomy of educational objectives*?
4. What is the type of assessment instrument (i.e. multiple-choice, authentic assessment, essay, etc.) that would best serve the needs of the NAIT Certification examination?

Assumptions of the Study

This study was based on the following assumptions:

1. There is a core of skills needed by industrial technologists in entry-level industrial technology positions.
2. The core content, subject area knowledge and skills of industrial technologists can be identified by NAIT-accredited institution representatives and by professional industrial technologists working in business and industry.
3. The respondents selected for this study possess the expertise representative of the target population of industrial technologists.

Delimitations of the Study

The study was delimited to addressing only the following:

1. NAIT-accredited Bachelor of Science baccalaureate degree programs.

2. General Industrial Technologist degree programs.
3. Job and tasks analyses for industrial technologists.

Limitations of the Study

The study was limited to the following:

1. The responses of representatives who are considered experts in their field based on number of years, experience, and academic interest at NAIT-accredited institutions.
2. The responses of Industrial Technology Industrial Advisors and NAIT-accreditation team members of NAIT-accredited institutions and programs.

Procedure of the Study

This study uses the Delphi technique, which is a survey procedure for collecting group consensus and judgmental data (Worthen & Sanders, 1987). Olaf Helmer of the Rand Corporation developed the Delphi technique in 1963.

A two-round modified Delphi design was used in this study. Delphi panelists were asked to respond to an open-ended on-line questionnaire to identify core subject and competency areas. Additionally, panelists were asked to include any other subject areas that were not listed on the survey. During the second round, the panelists were asked to rank core, subject, and competency areas identified in the first-round survey. The researcher served as the Delphi moderator.

The population for this study was a sample of NAIT accreditation team members and industrial technology professionals who serve as industrial advisors to NAIT-accredited institutions. The two-round Delphi panel of expert asked the panelists to rate competencies within each core area.

This study utilized a mixed methodology that is both quantitative and qualitative. Delphi panelists' responses were statistically analyzed to determine the interquartile range and median of panelists' responses (Martino, 1972). This study utilized the same statistical methodology to indicate the median and interquartile range and percent of occurrence for each item response on the Delphi questionnaire. An analysis of variance (ANOVA) based on the eta-squared statistic was conducted to provide evidence of significant differences between academic and vocational perceptions of the importance of core and subject competency areas.

Definition of Terms

Certification: A voluntary process to recognize an individual's mastery of a profession.

Competency: Manipulative and cognitive skills performed at levels which meet accepted standards for success at the entry-level (Harris & Grede, 1977).

Delphi Technique: A data-collection method for organizing and sharing expert opinion through questions and responses. Each member of a panel receives a questionnaire that is administered in an iterative fashion. After each iteration or round of the questionnaire, each panel member provides some form of feedback in which the panel member is asked to reevaluate his or her responses to the previous round.

Industrial Technology: A field of study designed to prepare technical and/or management oriented professionals for employment in business, industry, education, and government. Industrial Technology is primarily involved with the management, operation, and maintenance of complex technological systems while Engineering and Engineering

Technology are primarily involved with the design and installation of these systems (NAIT, 2000).

Licensing: The most restrictive form of professional and occupational regulation. Often referred to as right-to-practice. Under licensure laws, it is illegal for a person to practice a profession without first meeting state standards.

Test Blueprint: A template for a test that outlines the purpose of the exam, a description of the target audience, the total number of items on the exam, the number of items per domain/objective, the content outline, the exam format, and item types (Althouse, 2001).

CHAPTER 2. REVIEW OF THE LITERATURE

The literature relevant to the NAIT Certification test and test development may be categorized into seven areas: (1) certification programs; (2) NAIT and its accreditation process and standards; (3) the NAIT Certification Program; (4) test construction; (5) certification test development; (6) the Delphi technique as a data collection method, and (7) career trends in Industrial Technology. Studies in each of these areas were reviewed to establish the research base for the development of the test blueprint for the NAIT Certification examination.

Certification Programs

Each profession defines its certification program in its own unique terms. Barnhardt (1994) found that after reviewing 450 certification programs, there is no one single definition to classify every program. Many, although not all, certification programs use education and experience as certification criteria. The designators used for certification differ in meaning as well as the criteria established to define them. For example, the designator Certified Public Accountant is actually a state-issued license (Barnhardt, 1994). Understandably, the National Certification Commission cautions against using credentials, certification, licensure, standards and accreditation interchangeably (Jaffeson, 2001, January). Certification is voluntary and provides assurances about an individual, while accreditation provides assurances about institutions. Licensure and standards programs are managed by a state or government agency. Licensure serves to restrict a profession to individuals who meet minimum state requirements (Barnhardt, 1994). Credentials and competency exams imply that individuals are "guaranteed" to perform at certain prescribed levels (Jaffeson, 2001, January).

Certification programs are managed and governed by professional associations. A certification board is comprised of elected board officers, appointed committees, general members and practitioners who have the ultimate authority and responsibility for an association's certification program (Jaffeson, 2001, January).

Over 1500 certification programs in the United States represent a wide range of industries and professions including; business, management, accounting, finance, human resources, law, logistics, planning, insurance, marketing, communications, security, real estate, hospitality and travel, computers, and engineering (Barnhardt, 1994).

Companies can use certification programs as an assessment tool to determine job knowledge, the level of an individual's dedication to their profession, to verify experience, and as a training resource (Barnhardt, 1994). Certification programs also serve an accountability function by holding an employee accountable for his or her level of competence in their occupation. Others see professional certification programs as a natural outgrowth of the "Quality" movement. Examples of certified professionals include Certified Specialist in Analytical Technology, Certified Quality Engineer, Certified Reliability Engineer, Certified Cost Engineer, Certified Computer Professional, Certified Knowledge Engineer, and Certified Human Factors Specialist.

The Society of Manufacturing Engineers (SME) Manufacturing Engineering Certification is a program for professional documentation and recognition of an individual's manufacturing-related knowledge, skills, and capabilities. SME offers three certifications:

Certified Manufacturing Technologist, Certified Manufacturing Engineer; and Certified Enterprise Integrator option (Tillman, 1989).

Manufacturing is not the only industry to establish certification programs. During the past ten years, certification programs have become increasingly popular. In 1994, four pharmacy associations collaborated to form a single, consolidated voluntary national certification program, the Pharmacy Technician Certification Board (PTCB). Since 1995, PTCB has certified more than 54,000 pharmacy technicians through the Pharmacy Technician Certification Examination (Murer, 2000).

In a report from Drake Training & Technologies, the number of certification programs in information-technology has increased ten-fold between 1993 from 1994 (Merrill, 1994). Software certification examinations such as Microsoft's™ Certified Professional program, Certified Oracle™ Engineer, and the certified Novell™ Engineer are representative of popular computer application certification programs made available in recent years.

Business and industry observers site the relevance and need for certification programs. Peluso (2000), corporate counsel for the Professional Examination Service, stated that certification programs enable employees in various fields to advance their value and appeal. Such programs also provide the public with more confidence in quality of work. Peluso added that association–sponsored professional certification programs serve a multitude of purposes for many stakeholders, including the general public, employers, and certificants. Schrage (2000) in *Fortune* argued that a degree alone does not tell an employer what a job applicant can actually do. For example, Schrage stated that a computer science *cum laude* baccalaureate does not describe the digital abilities of its recipient. Schrage pointed out that certification will give academic programs and degrees meaning in the marketplace.

The NAIT Certification Program

NAIT established a certification program in 1991. The NAIT Certification Board and Certification Committee coordinate and conduct all certification activity. In 1991, the seven-member committee developed initial certification guidelines and procedures that the Certification Board subsequently approved. The original certification guidelines were intended to encourage NAIT graduates and certified individuals to continue professional development activities. The Certification Board decided to provide a NAIT certification examination program as a way to certify professionals who did not meet original certification criteria and to potentially use the aggregated examination results of graduating Industrial Technology baccalaureate students to assess the technical management portions of these programs.

Industrial Technology

Industrial Technology academic programs prepare students for technical management positions in areas such as industrial planning, production supply, product market research, and technical sales. Industrial technologists typically combine skills and knowledge that are characterized in an area between engineering and management (Tillman, 1989).

According to NAIT's definition, careers in industrial technology typically involve the application of theories, concepts, and principles found in the humanities, social, and behavioral sciences, including communications skills. Careers in industrial technology also involve the understanding of theories and the ability to apply the principles and concepts of mathematics and science and the application of computer skills. Industrial technologists also complete an area of specialization. Examples of such specialization areas include electronic data processing, computer aided design, manufacturing, construction, printing, transportation, and safety.

Due to rapid changes in technology and its uses, and the changing definition of "industrial technologists," it has become necessary to reevaluate the structure and content of the NAIT certification examination. An Industrial Technology curriculum combines liberal education coursework with professional-level technical management coursework.

Test Development

Educational and psychological considerations are the basis for all current test development and have been the target of extensive scrutiny and criticism by those who are outside as well as within the profession (AERA, APA, & NCME, 1985). To provide standards in test development, AERA APA, & NCME (1985) state the following in Standard 3.1:

> Test and testing programs should be developed on a sound scientific basis. Test developers should compile the evidence bearing on a test, decide which information is needed prior to test publication or distribution and which information can be provided later, and conduct any needed research (Primary). (p. 25)

The purpose of the test development standards is in part to strengthen current testing practices and to anticipate problems posed by new testing and innovative developments such as the use of learning styles inventories to prescribe educational treatments, computerized adaptive and interactive testing and multimedia test presentations, and computerized interpretations to name a few (AERA, APA, & NCME, 1985). Each step in the process ensures the test is both valid and reliable and is of crucial importance.

The development of certification examinations has its roots in early psychological testing. Beginning in 1963, in response to a lawsuit, the U.S. Department of Labor issued instructions to government contractors to provide definite empirical data demonstrating evidence of content-related validity for all tests that are used to determine qualifications for hire, transfer, or promotion in nonprofessional, technical, and managerial occupations, thus putting psychological testing procedures in the framework of government regulation (DuBois, 1970).

Sponsors of national certification and licensure examinations typically adhere to the same standards for educational and psychological testing as articulated in the Standards for Educational and Psychological Testing (AERA, APA, & NCME, 1985). NOCO, NCA, and NCCA are national licensure and certification associations and have prescribed standards for the administrative procedures of certification. The Standards maintained by the AERA, and NCME more extensively address educational test development issues. The test development process is both long and lengthy. Typically, there are ten steps involved in the test development process (Althouse, 2001):

1. Conducting job and task analysis
2. Developing the test blueprint
3. Developing items
4. Reviewing and validating items
5. Assembling and delivering beta exams

6. Analyzing beta exams results
7. Constructing equivalent exam forms
8. Establishing the passing score
9. Administrative/scoring operational exams
10. Providing ongoing test maintenance

Ensuring Psychometrically Sound Tests

Validity and reliability are the most important considerations in developing psychometrically sound tests. Validity refers to the appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores development (AERA, APA, & NCME, 1985). Reliability refers to the consistency of measuring whatever the test is intended to measure (Wiersma & Jurs, 1985).

Validity

Validity is defined by Messick (1995) as, "An overall evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and action based on the test score other modes" (p. 741). In other words, validity indicates the degree to which a test is capable of achieving certain aims (Issac & Michael, 1981).

There are three main types of validity: construct-related validity, criterion-related validity, and content-related validity. The most relevant type of validity to consider in certification content development is content validity. For the purposes of certification test content development, the standards state that only content validity, one issue of reliability that will be explained in a later section, need be considered.

Content-related validity makes evident the degree to which the items, tasks or questions on a test are representative of the domain of that which is to be tested. One method of achieving content validity is to rely on expert judgments to assess the relationship between the test and the domain of content (AERA, APA, & NCME, 1985).

According to Standard 11.1 (AERA, APA, & NCME, 1985):

> The content domain to be covered by licensure or certification test should be defined clearly and explained in terms of the importance of the content for competent performance in an occupation. A rationale should be provided to support a claim that the knowledge or skills being assessed are required for competent performance in an occupation and are consistent with the purpose for which the licensing or certification program was instituted. (p. 64)

Issac and Michael (1981) state that the content domain can be considered to comprise a definition of the achievement that is to be measured by a test. The test blueprint constructed in the current study for the NAIT Certification examination will, in part, define the universe or domain of test content using subject matter experts to ensure content-related validity.

Reliability

Reliability is defined as a measurement of consistency. Reliability provides information on the degree to which the instruments' test scores are free from errors of measurement (AERA, APA, & NCME, 1985). Standard 11.3 of AERA, APA & NCME (1985) test standards states that estimates of the reliability of licensure and certification decisions should be provided. However, in certification test content development, the reliability of the decision of whether or not to certify is of primary importance. Here, the reliability of the decision of whether or not to certify is an issue for the NAIT Board of Certification. The standards for decision reliability are needed when the actual test items are written when determining cut scores.

General Guidelines for Developing Certification Tests

The general guidelines for developing certification tests suggest (a) conducting a job analysis of professional practice; and (b) developing test specifications or a test blueprint that is aligned with job and task analysis (Althouse, 2001). The remaining steps are identical to the construction of any type of test.

"Certification allows its participants to define their profession, to establish its standards of performance and knowledge, and to create an objective standard of quality to which other in their profession can aspire" (Pare, 1996, p. 2). Additionally, the U.S. Educational Resources Information Center (1998), advises that assessment of certification programs is typically designed to lend creditability to and support the training and professional growth of those working within an occupation and or profession. Given this purpose of establishing one's ability to perform in an occupation or profession at a minimum level, it is critical that the tests are job-related (Pare, 1996).

The test blueprint is a defined set of test specifications. The test specifications state what is hoped to be measured and by what methods (Wood, 1991). Developing a certification test is a lengthy and difficult process that involves ensuring that the test is both valid and reliable.

NOCA & NCCA (2000) reiterates the need to define performance domains and tasks-related necessary knowledge and skills and use them to develop test specifications. AERA, APA, & NCME (1985) states that determining test content should include a formal job analysis to establish job-relatedness. Formal job analysis and identifying performance domains can be conducted in a number of ways: (1) using committees of representative experts to define performance domains, tasks, and associated knowledge, including a review of related practice, (2) reviewing information from a previous study, (3) rating scales to identify and select critical performance domains, tasks, and associated knowledge and/or skills, or (4) collection of job/practice using logs, observations of practice, and/or interviews (NOCO & NCCA, 2000).

Once a method of conducting a job analysis is determined, developers need to consider the testing methodology that serves the purposes of certification.

Examination Methods

Over the years there has been controversy over the merits of criterion-referenced tests and norm-referenced tests (Isaac & Michael, 1981). Wiersma & Jurs (1985) concluded that interpretations, not characteristics, provide the distinctions between the two types of tests. Wiersma and Jurs (1985) argued that the interpretation of the test score determines whether the test is criterion-referenced or norm-referenced.

Criterion-referenced tests

Criterion-referenced tests reference an individual's performance to some criterion of performance level (Wiersma & Jurs, 1985). Criterion-referenced tests involve the notion of a defined behavior domain, meaning that an individual's performance on a test is referenced to a defined group of behaviors. A criterion-referenced test yields a rating of each student's level of mastery of the performance domain or behavior domain that the test has been designed to cover (Isaac & Michael, 1981). The level of mastery is usually indicated by the percentage of items answered correctly among all possible items.

Norm-referenced tests

In contrast, norm-referenced test interpretation seeks to differentiate or to discriminate among individuals of a defined group on whatever is being measured. A norm-referenced test compares an individual's score to a normative group score (Wiersma & Jurs, 1985). The norm group is representative of examinees of a given age, profession, or occupation when applied to certification testing.

Differences between norm-referenced and criterion-referenced testing

In examining the differences between norm-referenced tests and criterion-referenced tests it seems that norm-referenced tests are more applicable for general and comprehensive information while criterion-referenced tests tend to focus on a specific group of learners' behaviors. Criterion-referenced test scores are usually given in percentage of right and wrong answers that indicates mastery or lack thereof, while norm-referenced tests test scores are transformed to positions within the normative group for comparison (Wiersma & Jurs, 1985). Isaac & Michael (1981) stated that in choosing one form of test over the other, one should consider the appropriate use of the measurement requirements, whether the test is to be used for certification, intelligence testing, or a classroom semester exam, etc.

Certification Tests

Certification exams usually fall into one of five types: (1) linear multiple-choice examinations; (2) the adaptive response multiple-choice examinations; (3) practical examinations; (4) computer-based simulation examinations; and (5) essay-form or constructed response item examinations (Peluso, 2000).

The linear multiple-choice exam is offered as both a paper-and-pencil test and a computer-based format. It is the most frequent format used in certification tests. These types of test questions can adequately assess conceptual, analytical, and factual information (Jaffeson, 2001, February). The typical design of a multiple-choice question consists of a question (stem) and four or five possible responses. One of the responses is the best answer, often called the modifier, and usually the other responses are called distracters. Often, two of the distracters are clearly incorrect, while one response is better but not the correct answer. Haladya (1995) recommends the use of multiple-choice tests for certification because multiple-choice testing allows for a range of questions that can be used for measuring varying cognitive levels. Computer adaptive tests (CATs) often use a multiple-choice format. These tests are offered in a computer-based format. The computer adapts itself to the examinee's performance by asking multiple-choice questions of predetermined difficulty. If the examinee answers correctly, a more difficult question is asked next. If the examinee answers this question incorrectly, a less difficult question is asked. By using this procedure throughout the test, the computer is able to track the examinee's competency level.

Practical examinations or authentic assessments measure competency by requiring examinees to perform discrete tasks. Practical tests measure how well an individual can perform in a controlled situation. For example, requiring medical nursing students to demonstrate a bandage-wrapping procedure.

Computer-based simulation examinations are similar to practical examinations, except that the tasks are performed on a computer. Aircraft flight simulation or stock trading games are examples of computer simulations. This type of examination is expensive to develop and administer.

Essay format examinations allow examinees to write detailed responses to questions that allow for competency judgments. In this type, there is a fair degree of latitude a grader may have in evaluating an examinee's performance.

Content specifications

Test content specifications give the test item writer directions for writing the actual test items. The specifications should include: (1) A description of the content areas that are to be tested; (2) a statement of the objectives or mental processes to be assessed; and (3) a description of the relative importance of (1) and (2) to the overall test (Osterlind, 1998). The test blueprint is the plan of stratification of content areas to be included on the test, which is then followed in creating the sample test (Thorndike, 1971).

A suitable way to establish a set of test content specifications is in terms of a table (Osterlind, 1998). The table should contain the three basic elements of content specifications: content, processes, and the importance of each. Different examples of content specifications tables are listed in the literature. Generally, content specification tables list the major content areas on the left side and the intellectual processes to be tested across the top of the table.

Bloom's *Taxonomy*

In 1956, a group of educational psychologists headed by Benjamin Bloom developed a classification of levels of intellectual behavior important in learning (Bloom, et al, 1956). Today, Bloom's *Taxonomy of educational objectives* influences many achievement tests' specifications and has had a standardizing effect within and across subjects (Wood, 1991). There are two additional levels that Bloom's team developed along with the cognitive levels of *Taxonomy*. Bloom et al. also identified the affective and behavioral psychomotor domains. The affective domain is concerned with interests, attitudes, opinions, appreciations, values, and emotions. The affective domain is essentially for the purpose of changing attitudes and behavior rather than to transmit information. The psychomotor domain focuses on motor skills. Hand-writing, reading, industrial training such as keyboarding, industrial technology, and performance in science, art and music are all classified under the psychomotor domain (Allen, 1998).

Bloom identified six levels within the cognitive domain of learning, ranging from simple through increasingly complex and abstract cognitive levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. (Bloom, et al., 1956). Bloom's *Taxonomy* is the most widely used process to identify and label levels of cognitive processes, and various modifications of the *Taxonomy* have been used extensively for the past two decades by developers of many current popular tests (Osterlind, 1998).

The cognitive levels identified in Bloom's *Taxonomy* and the skills that demonstrate each level are described in Table 3. Despite its popularity, Bloom's *Taxonomy* has been

Table 3. Bloom's six levels of cognitive domain

Competence	Skills Demonstrate	Verb Descriptors
Knowledge	Observation and recall of information knowledge of dates, events, places knowledge of major ideas	arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce, tabulate, quote
Comprehension	Understanding information grasp meaning translate knowledge into new context interpret facts, compare, contrast, order, group, infer causes	classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate, summarize, estimate, differentiate
Application	use information use methods, concepts, theories in new situations solve problems using required skills or knowledge	demonstrate, choose, apply, employ, illustrate, interpret, operate, solve, classify,
Analysis	seeing patterns organization of parts recognition of hidden meanings	analyze, appraise, calculate, categorize, arrange, compare, examine, experiment
Evaluation	compare and discriminate between ideas assess value of theories, presentations make choices based on a presentation	appraise, argue, assess, defend, estimate, convince, explain, summarize

(Bloom, Englehart, Furst, Hill, & Krathwohl, 1956)

labeled difficult to use because Bloom's descriptors do not easily lend themselves to simple test item construction at the high-end taxonomy levels of analysis, synthesis, and evaluation.

Another problem with Bloom's taxonomy is that there is an inherent difficulty in validating the properties of the levels within the taxonomy. Madaus, Nuttal, and Woods (1973) believe that Bloom's scheme has no structural hierarchy beyond what can be explained by a general intelligence, or "g" factor. Wiersma and Jurs (1985) cite the unfortunate position of "Knowledge" in Bloom's Hierarchy. They argue that acquiring knowledge and learning how to think are identical goals, and that knowledge is of a higher order than a "mind stuffed with memorized facts." According to Wiersma & Jurs, (1985) a better term for Bloom's lowest level would be recall or recall and recognition.

Delphi Technique

The Delphi technique is a data collection method that uses panel experts to gain group consensus while limiting the disadvantages of group interaction (Issac & Michael, 1981). The panel members who participate arrive at an emerging consensus opinion or position. The technique allows for each member to work toward the emerging consensus privately and to reconsider their initial position(s) in light of the group trends and make any adjustments as deemed appropriate (Issac & Michael, 1981).

According to Martino (1972), some of the disadvantages of the traditional round-table discussions are:

1. The power of a persuasive or prestigious individual to shape group opinion.
2. The bandwagon effect of a majority of opinion.
3. The vulnerability of group dynamics to manipulation.
4. The unwillingness of individuals to abandon publicly stated positions.

The Delphi technique is distinguished by three features: (a) anonymity; (b) iteration with controlled feedback; and (c) statistical group response that eliminate some of the disadvantages of group interaction. Anonymity is controlled through the use of a questionnaire. Respondents are not able to identify other panel members or their responses, allowing individuals to change their opinions without publicly announcing that they have done so. Feedback is controlled through the moderator, who draws out only those pieces of information that are relevant to the issues. This eliminates arguments and continual restatement of the problems among panel members. The use of statistical group response includes the opinions of the entire group. The group's responses are represented in terms of the median and quartile ranges, thereby taking the median and spread of opinion into account (Martino, 1972).

The Delphi technique has been used primarily for technological forecasting, yet it has also been used in many other contexts in which judgmental information is indispensable. These include normative forecasts, the assessment of values and preference, estimates concerning the quality of life, simulated and real decision-making (Helmer, 1975). It has also been used for general planning, curriculum planning, forecasting, forming policy, and identifying problems (Uhl, 1983).

Delphi process

The Delphi process is arranged so that each panel member receives a series of questionnaires. Each time a questionnaire sent to panel members it is called a "round". Usually, there are three to four rounds per Delphi study. According to Issac & Michael (1981), the typical sequence of events in the Delphi process is:

1. Identify the group members whose consensus of sought. The representative should be proportionately sampled.
2. *Questionnaire One* – Have each member generate a list of goals and issues of concerns under study. Edit the results and prepare *Questionnaire Two* using the results formatted so that items can be used for ranking and/or rating items.
3. *Questionnaire Two* –Have each member rate or rank each item.

4. Present the results from *Questionnaire Two* in the form of *Questionnaire Three*, showing the preliminary level of group consensus to each item and repeating each member's earlier response. The respondents rank or rate the items a second time, now aware of the preliminary group trend. For each item where the individual differs from the group, and chooses not to change his or her position on *Questionnaire Three*, the respondent should provide a brief explanation.
5. The results from *Questionnaire Three* are used for *Questionnaire Four* showing the groups' level of consensus for each item and repeating each members' rating or ranking along with a list of the areas where there is dissent from the prevailing group position.
6. Each member rates or ranks each item a third and final time in light of the emerging pattern of consensus and the reasons for dissent.
7. The results from *Questionnaire Four* are tabulated and presented as the final statement of group consensus.

Identifying and choosing panel members is a crucial step in the process. Martino (1972) suggested that a panel of experts be configured to reflect the most knowledgeable professionals in their particular field. (Martino, 1983) suggested seeking those who had been honored by professional societies, published a number of papers, and/or held a professional office.

The number of experts chosen to make up the panel depends on the intent and purposes of the study. An experimental study of Delphi groups found that the average group error is effectively lowered, and reliability increased, with a group size over 29. However, groups of less than 10 have been reported (Dalkey, 1968).

Variations of the Delphi technique

The Delphi technique can be modified from its typical design. Modified Delphi procedures have often increased or decreased the number of rounds. However, modification to the Delphi should maintain the three characteristics that were originally intended to eliminate some of the disadvantages of group censuses activity i.e. anonymity, iteration, and statistical response (Martino, 1972). In regards to the number of rounds, Martino (1972) noted:

> The basic method included four rounds of questionnaires. Some have involved as many as five rounds. The general finding is that by the end of four rounds, the panel has reached as much agreement as it is ever going to reach. A number of experiments with short sequences, have however, shown that in many cases, there is no advantage in going beyond two rounds (p. 27).

Criticisms of the Delphi technique

The Delphi has been criticized as a qualitative research technique that is unsound and unfair (Hill & Fowles, 1975; Sackman, 1975). Critics of the Delphi technique argue that it does not have a theoretical base. Even Helmer (1975), the Delphi's developer, notes that although Delphi has many useful applications, it still lacks a completely sound theoretical basis. Helmer attributes this to the fact that, by definition, the Delphi uses expert opinion and that experts are often not available as experimental laboratory subjects.

Linstone and Turoff (1975) answer to criticism that questions the honesty of respondents as the same limitations associated with any research process that relies on respondents' opinion. However, there are areas of technology where no alternative to the use of expert opinion exists (Martino, 1972).

There may be new areas in science and technology where sufficient historical information does not exist, or areas where technological progress is more dependent upon the decisions of others than on technological potential itself (Martino, 1972). The Delphi, developed in the early 1960s, was ahead of the current application and use of qualitative research. Since the 1960s, qualitative research has gained wider recognition. Johnson (1995) suggests that technology educators "engage in research that probes for deeper understanding rather than examining the surface features" (p.4). Johnson also notes that qualitative methodologies are powerful tools for enhancing our understanding of teaching and learning, and that they have "gained increasing acceptance in recent years" (p. 4).

Qualitative Research Methodology

The Delphi technique is used in this study to identify the core content and subject areas for the NAIT certification examination. Hoepfl (1997) describes qualitative research as "phenomenological inquiry that uses a naturalistic approach that seeks to understand phenomena in context-specific settings" (p. 2). The late 1960s saw resurgence in the interest in qualitative research for educational research, called at that time "naturalistic inquiry" (Bogan & Biklen, 1982).

Qualitative research methods allow for emerging knowledge and are not dependent upon sample size and norm referencing. Qualitative research is particularly useful making meaning of emerging knowledge. This study focuses on: 1) identifying the core content for

NAIT Certification testing; and (2) identifying subject areas and levels of knowledge. Qualitative analysis of open-ended responses will aid in this process.

There have been numerous discussions on what is the core content of Industrial Technology. A perhaps unsurprising result given that there are 293 NAIT accredited programs and institutions that offer over 60 different curricula and specialty areas. Identifying core content that is inclusive and represents the general requirements for a baccalaureate degree in Industrial Technology is the focus of this study. Using the Delphi technique will aid in the discovery of emerging knowledge to identify core content and subject areas for the NAIT Certification exam.

Qualitative research

Qualitative research or naturalistic inquiry attempts to study people, places, and things in their natural settings, trying to make sense of, and interpret, events in terms of the meanings people bring to them (Denzin & Lincoln, 1994). Data are typically gathered in qualitative research in a natural setting through observation, interviews, visiting, and talking. The natural ways in which data are collected lends to the notion of naturalistic inquiry. Guba and Lincoln (1982) agree with this definition of naturalistic inquiry, but add that naturalistic inquiry encompasses much more than how and where one conducts inquiry. They state that, "naturalistic inquiry is a paradigm of inquiry; that is, a pattern or model of how inquiry is conducted" (p. 311). To understand Guba and Lincoln's stance, one should know and understand what a paradigm is. A paradigm is a model that has basic universal truths or assumptions that are inherent in its design (Guba & Lincoln, 1982). They further state that the universal truths or assumptions of naturalistic inquiry or qualitative research are that self-evident assumptions supporting naturalistic inquiry or qualitative research are multiple:

- Both the researcher and the participant share an influential position during the research,
- The resulting hypothesis are time and context-bound,
- The impact of multiplicity on events people and reality mean that all inferences and /or explanations of occurrences are continuously being shaped, and
- Because people shape events, circumstances, choices and research phenomena in their lives all inquiry is value-bound (p. 26).

A comprehensive definition of qualitative research was devised by Denzin and Lincoln (1994), who described qualitative research as follows:

> Quantitative research is multi-method in focus, involving an interpretative, naturalistic approach to its subject matter. Qualitative researchers study things in their natural settings, attempting to make a sense of, or interpret phenomena in terms of the meanings people bring to them. Qualitative research involves the studied use of and collection of a variety of empirical materials- case study, personal experience, introspective, life story, interview, observational, historical, interactional, and visual texts...that describe routine and problematic moments and meaning in individuals' lives. (p. 23)

Opponents of qualitative research argue that qualitative research is not valid because the findings in qualitative research cannot be generalized to a population under study and are "value-free." In quantitative studies, the research questions seek out a relationship among a small number of variables. In qualitative studies, research questions are typically oriented to cases or phenomena and seek patterns (Stake, 1995).

There are three major differences between qualitative and quantitative research: (1) the distinction between explanation and understanding as the purpose of inquiry; (2) the distinction between a personal and impersonal role for the researcher; and (3) the distinction between knowledge discovered and knowledge constructed (Stake, 1995). However, depending upon the purposes and the subject under study, either method conveys understanding and knowledge about a subject and may in fact enhance each other.

According to Stake (1995), a philosopher named Wilhelm Dilthey argued a century ago that science was not moving in the direction of helping humans understand themselves:

> Only from his actions, his fixed utterances, his effect upon others, can man learn about himself; thus he learns to know himself only by the round-about way of understanding. What we once were, how we developed and became what we are, we learn from the way in which we acted, the plans which we once adopted, the way in which we made ourselves felt in our vocation, from old dead letters, from judgments on which were spoken long ago. ... We understand ourselves and others only when we transfer our lived experienced into every kind of expression of our own and other people's lives. (p. 163)

The differences in qualitative and quantitative research are evident, but it should also be evident that qualitative research is a valuable tool when studying perceptions, attitudes, and in this study, while studying a particular case, the NAIT Certification examination. Qualitative research perhaps is a vehicle to lend understanding and knowledge in identifying the core content and subject areas for the NAIT Certification examination.

CHAPTER 3. METHODOLOGY

A two-round modified Delphi was used in this study. The number of Delphi rounds was determined based on the responses to the Rounds I and II surveys. The median, mean, and interquartile range was calculated for the Round II data. The interquartile range is a measure of dispersion. Outliers lay outside the interquartile range and signal unusual scores (Hinkle, Wiersma, Jurs, 1994). The interquartile range did not provide meaning, because there were no significant outliers in the data. Therefore, the interquartile range is not reported in this study. Additionally, because there were no significant outliers in Round II, two rounds were deemed sufficient, since the number of rounds should proceed until there is a high level of consensus among the panel members.

NAIT accreditation team members were chosen as to serve as Delphi panelists for identifying NAIT Certification exam test content because they receive training to ensure that NAIT institutional programs maintain accreditation standards. Twenty-three of these trained NAIT accreditation team members were contacted by telephone in July 2001, to request their participation in this study. In mid-August, NAIT accreditation team members were again contacted to ask for their participation in the study. Also in August, a list of Industrial Advisory Committee members was requested from NAIT accredited institutions located on the East and West coasts and the South and North of the United States in order to achieve a fair representation of different types of businesses and industries.

Population and Sample

The population and sample of this study were comprised of NAIT accreditation team members and Industrial advisors to NAIT-accredited institutions. A second population was comprised of professors and members of NAIT from NAIT-accredited institutions who were interested in certification and completed Round II of the Delphi survey at the NAIT National Conference in Dearborn, Michigan, October 31 through November 5, 2001. The second groups' responses were included in Round II data analysis.

Prior to carrying out the study, approval was sought and obtained from the Iowa State University Committee on the use of Human Subjects in Research. A copy of the signed approval and related e-mail letters to participants are exhibited in Appendix A.

Instrumentation

A modified two-round Delphi technique was used to obtain expert opinion through an electronically mailed questionnaire interaction. The first-round Delphi questionnaire asked respondents to list what they believe should be the core areas and subject areas that should be included on the Certification examination. The Round I Delphi asked for demographic information. The panelist's name, address, phone number, school, business, and area of specialization. A copy of the Round I Delphi survey is in Appendix B.

The second round asked the panel members to rate each core on a Likert-type scale: 1 = very high importance; 2 = high importance; 3 = neutral; 4 = low importance; and 5 = very low importance. Panelists were also asked to list the subject areas and any additional core and subject areas they believe should be included on the Certification examination. The Round II Delphi survey is exhibited in Appendix B.

CHAPTER 4. RESULTS

The results and findings presented in Chapter 4 identify: (1) the Delphi panelists perceptions of what are the core content and subject areas the NAIT Certification examination should focus on; and (2) compare the findings from the 1991 Delphi that identified the core content and subject areas with this current Delphi study.

The first-round Delphi was sent by e-mail to 23 NAIT accreditation team members and 23 Industrial Advisory Committee members. Eight panel members responded to the Round I survey. Although this would have been ostensibly a low response rate for a quantitative study that relies solely on random sampling for prediction, this study utilizes a panel of experts from a larger population who are considered experts in the field of Industrial Technology. The respondents are therefore posited to be representative of the body of knowledge in industry and at Industrial Technology programs.

This first-round Delphi survey asked panelist to list or describe core content areas that should be included on the NAIT Certification Exam. Respondents were asked to list or describe the level of cognition and skills needed by an entry-level employee who completes a baccalaureate degree in a general Industrial Technology program, without regard to specialty area. The panelists were essentially given a blank sheet to respond to the above question. Demographic data were requested, including name, school or business, address, work phone number, and area of specialization. The Round I survey was sent to the panelists via e-mail.

Four of the Round I respondents represent NAIT-accredited institutions and four respondents represent NAIT-accredited institution industrial advisory committee members. For the reasons previously mentioned, the eight panelists are considered to be an acceptable number to compose a panel of experts in Industrial Technology to identify core and subject area content for the NAIT Certification examination. The eight panel members are from various NAIT-accredited Industrial Technology academic programs and represent various technical areas of specialization in business and industry. Table 4 outlines the panelists' academic and technical areas of specialization.

The Round II survey was developed from the responses from the Round I survey. To avoid duplication of core subject area listings that were listed or described by the panelists, one descriptor was chosen for each subject area when duplicate descriptions were submitted. For example, one respondent identified applied calculus whereas another respondent indicated calculus I and II were important; therefore, calculus I and calculus II were chosen to represent the subject area. The list of core content identified in Round I is presented in Table 5.

Table 4. Round I Delphi participants' technical area of specialization

Accreditation Team Members	Industrial Advisory Committee Members
Industrial Management	Network Administrator
Manufacturing/Research	Graphic Communication
Integrated Manufacturing Technology	Manufacturing Technology/Polymers
Manufacturing/Safety & Health	Electronics

Table 5. Core content areas identified in Round I

Core Content Area
Calculus
Chemistry I
Chemistry II
College Algebra
Computer Integrated Manufacturing
Computer Programming
Cost Accounting
Desktop Publishing
Electrical
Electronic
Fundamentals of Management
Fundamentals of Organizational Behavior
Human Resource Management
Industrial Psychology
Industrial Supervision
Internship
Leadership Skills for Supervisors
Manufacturing Automation
Manufacturing Technology
Material Handling
Materials Testing (Strength of Materials)
Multimedia production, i.e., slide shows, presentation
Physics I
Organizational Behavior
Physics II
Principles of Industrial Accounting
Product Research and Design
Quality
Safety Management
Special Processes in Manufacturing
Statistics
Team Work
Technical Graphics and CADD
Technical Writing
Time and Motion Study
Verbal communication
Written Communication

The Round II survey lists 37 core content areas identified in the Round I Delphi survey and asks respondents to rate each area on a Likert-type scale: 1 = of very high importance, 2 = of high importance, 3 = neutral, 4 = of low importance, and 5 = of very low importance. Space was included for respondents to list any subject areas that they believed should be included on the test and to indicate the levels of cognition for each subject area. For example, if a panel member perceived that Leadership Skills for Supervisors was very important, they were to list the levels of cognition an examinee was expected to master in that area. Thus, Round II was a web-page survey that was sent to the 8 panel members as a web link as part of an e-mail introducing the survey.

Additionally, at the NAIT Conference in Dearborn, Michigan held October 31, 2001 to November 5, 2001, six professors from five NAIT-accredited institutions completed the Round II Delphi survey. The six conference attendees were asked to add any core and content areas that they believe should be included on the NAIT Certification examination that were not identified on the Round II survey.

The data were divided into two groups. Group I, representing academics at NAIT-accredited schools and programs; and Group II, representing industry professionals.

The median values for Group I and Group II are in Table 6. A comparison of the median value for each core content area for the combined groups is displayed in Table 7. The interquartile range was not reported because there is little variance between groups and in the median values, thus the interquartile range has little meaning in the interpretation of the

Table 6. Median of responses for Round I Delphi Groups I and II

Core Content Area	Group I Median	Group II Median
Calculus	3.0	3.0
Chemistry I	3.0	3.5
Chemistry II	3.0	3.0
College Algebra	2.0	4.0
Computer Integrated Manufacturing	3.0	4.0
Computer Programming	3.0	3.5
Cost Accounting	3.0	4.0
Desktop Publishing	2.5	2.5
Electrical	3.0	4.0
Electronic	2.5	4.0
Fundamentals of Management	4.0	5.0
Fundamentals of Organizational Behavior	3.0	4.0
Human Resource Management	4.0	4.0
Industrial Psychology	3.0	3.0
Industrial Supervision	4.0	5.0
Internship	3.0	5.0
Leadership Skills for Supervisors	4.0	5.0
Manufacturing Automation	2.0	4.0
Manufacturing Technology	4.0	4.0
Material Handling	3.0	3.5
Materials Testing (Strength of Materials)	2.5	4.0
Multimedia Production, i.e., slide shows, presentation	3.0	2.0
Organizational Behavior	3.0	4.0
Physics I	2.5	3.5
Physics II	2.5	3.5
Principles of Industrial Accounting	3.0	4.0
Product Research and Design	2.5	4.0
Quality	3.0	5.0
Safety Management	5.0	4.5
Special Processes in Manufacturing	3.0	3.5
Statistics	3.0	4.0
Team Work	4.0	4.5
Technical Graphics and CADD	4.0	4.5
Technical Writing	3.0	5.0
Time and Motion Study	3.0	3.5
Verbal Communication	3.0	5.0
Written Communication	2.0	5.0

(KEY: 1 = of very low importance; 5 = of very high importance)

Table 7. Combined groups' core content area median reported in Round II Delphi survey

Core Content Area	Median
Calculus	3.0
Chemistry I	3.0
Chemistry II	3.0
College Algebra	3.5
Computer Integrated Manufacturing	4.0
Computer Programming	3.0
Cost Accounting	3.0
Desktop Publishing	2.5
Electrical	3.0
Electronic	3.0
Fundamentals of Management	4.0
Fundamentals of Organizational Behavior	3.0
Human Resource Management	4.0
Industrial Psychology	3.0
Industrial Supervision	4.0
Internship	3.0
Leadership Skills for Supervisors	4.0
Manufacturing Automation	4.0
Manufacturing Technology	3.5
Material handling	3.0
Materials Testing (Strength of Materials)	3.0
Multimedia Production, i.e., slide shows, presentation	2.5
Organizational Behavior	3.0
Physics I	3.0
Physics II	3.0
Principles of Industrial Accounting	3.5
Product Research and Design	3.0
Quality	4.0
Safety Management	5.0
Special Processes in Manufacturing	3.0
Statistics	3.5
Team Work	4.0
Technical Graphics and CADD	4.0
Technical Writing	4.0
Time and Motion Study	3.0
Verbal Communication	4.0
Written Communication	4.0

(KEY: 1 = of very low importance; 5 = of very high importance) responses. The scale was recoded as: 5 = of very high importance; 4 = of high importance; 3 = neutral; 4 = of low importance; and 1= of very low importance, to facilitate the interpretation of the median values. The core content areas that were rated very important and important were: (1) Industrial Supervision; (2) Leadership Skills for Supervisors; (3) Team Work; (4) Fundamentals of Management; (5) Human Resource Management, (6) Technical Graphics/CADD; (7) Safety Management; (8) Quality; (9) Technical Writing; (10) Written Communication; (11) Verbal Communication; (12) Manufacturing Automation; and, (13) Computer-Integrated Manufacturing. The other core content areas were rated as being neutral or neither important nor unimportant to NAIT Certification test content.

Group Differences Reported in Core Content and Subject Area

A measure of variance was conducted due to the perceived differences in some of the means between Group I and Group II panelists. The eta-square statistic is a statistical significance test that assesses the reliability of the association between an independent variable and dependent variable. The independent variables in this study are Groups I and II, and the dependent variables are the core content areas. "The strength of the association measures *how much* association there is" (Tabachnick & Fidell, 2001, p. 52). The formula for eta-square is as follows:

$$\eta 2 = \frac{SS_{effect}}{SS_{total}}$$

The SS_{total} is the sum of the squares of the dependent variables and SS_{effect} is the sum of the squares of the independent variables. The η^2 is the squared point biserial correlation between the continuous variable, or the dependent variable and the dichotomous variables, or independent variables. The eta-squared values indicate that several of the variables are significant in terms of their impact. Specifically, because the eta-squared statistic measures the amount of variance in a dependent variable that is controlled by an independent variable, it might be argued by some that it is a more important index of "significance" than is probability.

The following core content areas showed high eta-squared values (.25 or above): Electronics, and Electrical, Manufacturing Automation, Special Process Manufacturing, Materials Testing, Manufacturing Technology, Physics I, Written Communication, Verbal Communication. Table 8 indicates the core content areas with eta-squared values .25 or above ($\alpha = 0.5$). The findings point toward the higher importance industry representatives place on the core areas listed in Table 8 as compared to academicians.

Table 8. Significant core content areas with high eta-squared values of .25 and above

Core Content Area	Measure of Association (Eta Squared)
Electronics	.373
Electrical	.255
Automated Manufacturing	.327
Special Process Manufacturing	.296
Material Testing	.300
Manufacturing Technology	.276
Physics I	.252
Verbal Communication	.277
Written Communication	.384

Core Content Identified for NAIT Certification Exam

Overall 13 core content areas were rated as either of very high importance or of high importance (4.0 – 5.0). The 13 areas recommended for NAIT Certification test content are: (1) Leadership Skills for Supervisors; (2) Teamwork; (3) Fundamentals of Management; (4) Safety Management; (5) Computer-Integrated Manufacturing; (6) Technical Graphics/Computer-Aided Design and Drafting (CADD); (7) Quality; (8) Electronics; (9) Human Resource Management; (10) Technical Writing; (11) Written Communication; (12) Verbal Communication; and (13) Industrial Supervision. The other core areas received either a neutral, low importance or very low importance rating, and were not considered as NAIT certification examination content in this study. The levels of cognition for the 13 content areas were then analyzed. The open-ended portion of the Round II survey was analyzed by coding using the six of levels of cognitive objectives set forth in Bloom's *Taxonomy*.

The 13 core content areas identified by the Delphi panelists all seem to require higher levels of cognition, including the ability to evaluate, synthesize, analyze, apply, and comprehend. Additional competencies were: know how to manage others in the workplace; effectively and appropriately communicate with others to motivate, guide, and lead in all areas including diversity; to provide leadership; cross-pollinate and cross-train skills over departments; and having such skills as accounting, human resource management, as well as a particular area of specialization.

Core and subject areas and Bloom's *Taxonomy*

The open-ended questions on the Round II survey asks respondents to list subject areas for the core content areas and to indicate the level of cognition for each subject area listed. Table 9 lists the core and subject areas specified by the Delphi panelists. The level of cognition is indicated upon analysis of the descriptors and information received from the respondents on the open-ended portion of the survey responses. The core and subject areas and the types and levels of cognition describe what is emerging as the perceived core of Industrial Technology content and knowledge and perhaps what distinguishes the field from science and engineering.

Table 9. The levels of cognition and percentage of test questions assigned to each core content area

Competency areas	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Computer-integrated manufacturing	100					
Fundamentals of management		20	50	30		
Human resource management		20	20		60	
Industrial supervision						
Leadership skills for supervisors	10	15		20	50	5
Manufacturing automation	25	75				
Quality	NR	NR	NR	NR	NR	NR
Safety management	NR	NR	NR	NR	NR	NR
Teamwork					75	25
Technical graphics/CADD			50	50		
Technical writing			75		25	
Verbal communication				30	30	40
Written communication			50		50	

NR= not reported

To make sense of the levels of cognition each core area represents, the frequency of each level as described by the panelist was calculated and a percentage of the number of questions was assigned to each level of cognition. The most important level of cognition that was deemed required for certification seems to be level 3, "Application" which impacted many of the core areas. For example, to demonstrate the level of cognition in technical writing, the ability to write clearly or the ability to write highly technical papers was described. The next most important level of cognition required was "synthesis." Synthesis was particularly important for Leadership Skills for Supervisors and Teamwork, where panelists considered interpersonal skills, motivating others, delegating, and defining cultural differences important. "Analysis", the third most important level of cognition, was particularity important for Fundamentals of management and Technical graphics/CADD. Panelists stressed the importance of the interpretation of drawings, developing design capabilities, organizing, planning and controlling. "Comprehension" was the fourth most important level of cognition where the understanding of the theories, principles and concepts of machine processes, and the understanding of electronic components were reported. "Evaluation", the sixth and highest level of cognition, was notable in the areas of Teamwork and Technical graphics/ CADD. Respondents recommended that the ability to evaluate drawings, develop team skills in others, facilitate teams, and identify roles and contribute to teams were important. "Knowledge", the first level, was the least frequently identified. However, a general knowledge of manufacturing technology and the general core in electronics were rated important by some of the panelists.

The 1991 Delphi Study conducted by the NAIT Certification Committee recognized eight core content areas for NAIT Certification: (1) Quality; (2) Production Planning and Control; (3) Industrial Supervision; (4) Industrial Finance and Accounting; (5) Industrial Safety; (6) Plant Layout and Material Handing; (7) Time and Motion Study; and (8) Industrial Communication.

The findings of the current Delphi study and the 1991 study are similar because both attempted to identify the core content of core technical management areas for certification purposes. The current Delphi findings identify communication skills as well as technical expertise required for certification. There are over 293 technical and management specialty areas across Industrial Technology programs nationwide. By focusing on a core of Industrial Technology content areas that all Industrial Technology programs should share as a body of knowledge, advertising Industrial Technology programs to business, industry, students, and practitioners would be facilitated.

By identifying the levels of knowledge required in each core area, it is expected that the findings of this study will make clearer the skills, abilities, and knowledge industrial technologists require for practice. NAIT-accredited institutions can begin to evaluate the need to adapt current course offerings to changes in real world needs of business and industry.

Summary of the Results Based on the Research Questions

Four research questions addressed the challenge to identify the core content for the NAIT Certification examination. Following is a summary of the results for each question.

Research Question 1: What are the core content and subject areas and related competencies that NAIT-accredited institutions recommend for the NAIT Certification examination?

Thirteen core content areas were identified for the NAIT Certification Exam: (1) Leadership Skills for Supervisors; (2) Teamwork; (3) Fundamentals of Management; (4) Safety Management; (5) Technical Graphics/CADD; (6) Quality; (7) Electronics; (8) Human Resource Management; (9) Technical Writing; (10) Written Communication; (11) Verbal Communication; (12) Manufacturing Automation; and (13) Computer Integrated Manufacturing. These content areas were rated by the Delphi Panelists as having high importance or very high importance, with a median value of 4 or above.

Research Question 2: Do the core content, subject areas, and related competencies identified by NAIT-accredited schools differ from what business and industry professionals view as the knowledge, skills, and related competencies required for entry-level industrial technologists?

There was a difference in identification of core content, subject areas, and related competencies areas by NAIT-accredited schools and business and industry. The higher median values reported by business and industry professionals indicate a preference for liberal arts core content and subject areas such as Physics, Written and Verbal, and Technical Communication. The measure of association, eta squared at the α=0.5 level, indicated that Group II which represented industrial technology working professionals, had a preference for certification testing to focus on: Written Communication, Verbal Communication, Physics I, Materials Testing, Manufacturing Technology, Automated Manufacturing, Special Process Manufacturing Electrical, and Electronics.

Research Question 3: What is the percentage of items that should be represented by each of the six domains as outlined in Bloom et al. (1956) Taxonomy of educational objectives?

See Table 9 for a listing of the levels of cognition and suggested percentage of test questions assigned to each core content area.

Research Question 4: What is the type of assessment instrument that would best serve the needs of the NAIT certification examination?

The type of test that would best serve the purpose of NAIT Certification are tests that adequately assess the preponderance of the cognitive objectives pointing toward testing the application of skills, knowledge, and ability. Practical and authentic assessments are recommended. Such tests measure how well an individual can perform in a controlled situation and include student portfolios and practical tests. This is especially true when such skills as verbal communication, teamwork, and guiding others are assessed by direct observation for demonstration.

Criterion-referenced tests would provide the format upon which an individual's performance on a test is referenced to a defined group of behaviors. Criterion-reference tests allow for establishing a defined group of behaviors that could become standards for the purposes of NAIT Certification testing.

CHAPTER 5. SUMMARY AND CONCLUSIONS

Summary

The primary purpose of this study was to develop a test blueprint that serves to identify core content, subject areas, and competencies needed to update the NAIT Certification examination. Eight core content areas were identified by the 1991 Delphi panel as common to NAIT-accredited Industrial Technology programs: (1) Quality Control; (2) Production Planning and Control; (3) Industrial Supervision; (4) Industrial Finance and Accounting; (5) Industrial Safety; (6) Plant Layout and Material Handling; (7) Time and Motion Study; and (8) Industrial Communications. A modified Delphi technique was used to identify current core content. Two Delphi Rounds were conducted in which 14 panelists identified 13 core competency areas: Leadership Skills for Supervisors, Teamwork, Fundamentals of Management, Safety Management, Technical Graphics/CADD, Quality, Industrial Accounting, Electronics, Human Resource Management, Technical Writing, Written Communication, Verbal Communication, and Manufacturing Technology.

Findings and Conclusions

Three research questions addressed the challenge to identify the core content areas for the NAIT Certification examination. The 13 competency areas that were identified reflect the current needs of business and industry, which consider graduates of Industrial Technology programs as experts who can lead others. These areas are in contrast to the eight core areas originally identified in the 1991 Delphi study by 11 panelists, which stressed specific technical competencies.

The findings of this study indicated a greater need for expanding an evaluative component regarding the use of information, particularly in written and verbal communication, especially how to communicate technical information to others. This is in line with the current needs of a growing informational society that is characterized by rapid advances in technologies and the need for higher levels of knowledge required of those who will lead in a complex world. Industrial technologists are at the forefront of this movement because of their unique blend of technology and management skills that are based on theory and application. The study provides further evidence that institutions of higher education continually need to strengthen the alignment of their professional curriculum with the needs of business and industry. Bloom's *Taxonomy* assists us in defining and describing learning objectives.

The current method of NAIT Certification Exam is multiple-choice examination. Authentic assessment methods are often too expensive for examinees. Although the panelists did not make direct recommendations as to the need for practical or authentic assessment, such a test may prove useful in NAIT Certification testing. Such exams would provide a method to assess the higher levels of cognition of Bloom's *Taxonomy*. The list of open-ended responses for each core content and subject area competencies is in Appendix C. Due to the high cost of authentic testing, alternative measures of providing practical testing could be conducted at the educational institutions prior to graduation as an integral component, ensuring competency in the identified core technical management areas.

Limitations

The current study was limited to the responses of 14 Delphi panelists. Therefore, the findings might not represent the perceptions of all NAIT-accredited institutions. The study was also limited in its number of Rounds. Additionally, six panelists who completed Round II did not complete the Round I, therefore, a lack of continuity may affect the outcome. Thus, the results of this study may not be applicable to the entire body of NAIT-accredited institutions; rather they might indicate a trend that could be explored further.

Recommendations

Based on the findings of this study, the following recommendations are made for practice and further research.

Greater emphasis should be placed on technical communication, oral, and written communications skills in Industrial Technology programs. Industrial technologists with baccalaureate degrees often become middle-level managers in business and industry. Therefore, the ability to lead and manage others as well as the environment is crucial to success in the world of work. Industrial technologists have something unique to offer as technologies rapidly advance and become more definitive; therefore, they must be able to communicate and share their expertise to enhance organizational growth. Having technically skilled personnel who can lead, manage and guide others is crucial.

The significant eta-squared values that measure the amount of variance in a dependent variable that is controlled by an independent variable indicated significant differences on how the groups rated core content areas. Industry representatives may perceive the needs of industry served more effectively by those areas they rated of being of higher importance. If that is the case, further study of business and industry needs would be useful. A larger sample size would improve provide more statistically robust results and quite possibly interesting findings on how business and industry versus academics view the Industrial Technology curriculum.

APPENDIX A: HUMAN SUBJECTS APPROVAL AND RELATED CORRESPONDENCE

Human Subjects Approval

Iowa State University Human Subjects Review Form

OFFICE USE ONLY
EXPEDITED ✓ FULL COMMITTEE ___ ID# [illegible]

PI Last Name Rowe **Title of Project** A Test Blueprint for National Association for Industrial Technology Certification Exam

Checklist for Attachments

The following are attached (please check):

13. ☒ Letter or written statement to subjects indicating clearly:
    a) the purpose of the research
    b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see item 18)
    c) an estimate of time needed for participation in the research
    d) if applicable, the location of the research activity
    e) how you will ensure confidentiality
    f) in a longitudinal study, when and how you will contact subjects later
    g) that participation is voluntary; nonparticipation will not affect evaluations of the subject

14. ☐ A copy of the consent form (if applicable)

15. ☐ Letter of approval for research from cooperating organizations or institutions (if applicable)

16. ☒ Data-gathering instruments

17. Anticipated dates for contact with subjects:

First contact
August 29, 2001
Month/Day/Year

Last contact
October 3, 2001
Month/Day/Year

18. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased.

November 10, 2001
Month/Day/Year

19. Signature of Departmental Executive Officer — Date — Department or Administrative Unit

Daniel [illegible]. Hounlocker 8/[illegible]/01

20. Initial action by the Institutional Review Board (IRB):

☐ Project approved ☒ Pending Further Review 8/22/01 Date ☐ Project not approved ____ Date

☐ No action required ____ Date

21. Follow-up action by the IRB:

Project approved ☒ 8/[illegible]/01 Date Project not approved ____ Date Project not resubmitted ____ Date

Rick Sharp
Name of IRB Chairperson

Rick Sharp
Signature of IRB Chairperson

8/30/01
Date

E-mail Correspondence

August 30, 2001

Sheila E. Rowe M.S.
101A IED T II
Iowa State University
Ames, IA 50011
515-294-3794
sheibo@iastate.edu

I am a doctoral candidate at Iowa State University. Under the direction of Dr. Dennis Field Chair of the National Association for Industrial Technologist (NAIT) Certification Committee, I am conducting a Delphi study to (1) update the current core content and subject areas on the NAIT Certification Examination, and (2) to develop a test blueprint that is consistent with the standards for certification test development. I have included you as a member of a panel of experts for this study because of your particular expertise. Your feedback is important to this process.

Industrial Technology is defined as a field of study designed to prepare technical and/or management-oriented professionals for employment in business, industry and government.

The certification program provides for certification of graduates from associates and undergraduate degree programs as well as faculty and Industry Technology professionals. NAIT Certification provides assurances about an Industrial Technologist's knowledge, application, and continuing professional development and promotes awareness about the expertise and educational background of Industrial Technologists.

The focus of this study is on NAIT Certification. We hope that you take the time to complete this survey because your input is needed to identifying technical and management core and subject areas.

This Delphi study allows for group consensus while maintaining individual anonymity. All responses are confidential. The first round of the Delphi study seeks input from the NAIT accreditation Team and industrial advisors that are considered experts in the field of Industrial Technology. We hope that you take the time to take part in this study because your input is needed to identify core and subject areas for the NAIT Certification Exam.

You are under no obligation to participate in this study and you may quit at any time. Your participation in this study is voluntary.

If you decide to participate in this study we hope that your will be able to return this survey by September 7, 2001 so that your responses are included in the first round analysis.

Two additional rounds will be mailed. Each survey should be returned within one week. The second round survey will mailed on September 12th and the final survey will be mailed on September 26, 2001.

Please return this survey no later than September 7, 2001.

If your have any questions please contact Dr. Dennis Field or myself at the addresses below. Thank you.

Sheila E. Rowe M.S.
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National Association of Industrial Technologists Core and Subject Area Delphi Survey

Please use the space to the right to complete the following information.

Your Name:	
Institution or Company Name	
Street Address	
Zip code	
Telephone Number	
Job Title	
Number of years employed	
Area of Specialization	

Please list and/or describe in the space below all core and subject areas that <u>Industrial Technology majors from baccalaureate degree programs, regardless of specialty area,</u> should be expected to know and should be included on the NAIT Certification Exam. Use as many pages or as much space as needed.

From: "Sheila E. Rowe" <sheibo@iastate.edu>
To: [redacted]
Sent: Friday, October 05, 2001 1:29 PM
Subject: Round II - NAIT Certification

[redacted]

Thank you again for your participation. Round II is a web-based survey. Please access the WebPage from the address below.

At the bottom of the survey click on the send answers box.

Please attempt to return the survey by October 19, 2001. If you have any questions, please contact me.

Thank you,
Sheila E. Rowe

http://survey.educ.iastate.edu/surveys/round2.htm

APPENDIX B: DELPHI QUESTIONNAIRE

NAIT CERTIFICATION
ROUND II

Thank you for completing the Round I Delphi survey. Thank you for support in this very important process.

Round II of the Delphi lists all of your responses from Round I. Duplicate listings of core subject areas were avoided by collasping duplicate course identifiers into one standard course description.

Now I ask that you rate the importance of each core area and list any subject areas you believe should be included on the test. For example if you believe electronics is of very high importance, important, or neutral, please indicate the subject areas and levels of knowlege of electronics that is important, for example is it sufficient to simply know or define what an analoue circuit is or is it important to be able to design analog circuits. This same descritions of the levels of knowledge for each core area is needed.

Scale

You may use words such as list, tell describe, tabulate, summarize, interpret, contrast, distinguish, discuss, apply, demonstate, solve, modify, classify, synthsize, create, construct, plan, argue, score, rate, predict. You may use any other desciptors that you believe adequately describe knowlege of subjects needed on the Certification test.

1 = very high importance, 2 = high importance, 3 = neutral , 4 = low importance, 5 = very low importance

1. **Industrial Supervision**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

____

____

____

2. **Leadership Skills for Supervisors**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

____

____

____

3. **Team Work**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

4. Fundamentals of Management

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

5. Fundamentals of Organzational Behavior

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

6. Industrial Psychology

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

7. Human Resource Management

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

8. Safety Management

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

9. Technical Graphics and CADD

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

16. **Statistics**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

17. **Physics I**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

18. **Physics II**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

19. **Chemistry I**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

20. **Chemistry II**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

21. **Material Handling**

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

22. Materials Testing (Strength of Materials)

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

23. Special Processes in Manufacturing

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

24. Cost Accounting

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

25. Principles of Industrial Accounting

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

26. Computer Programming

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

27. Multimedia production, i.e. slide shows, presentations

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

29. Desktop Publishing

❑ Very High ❑ High ❑ Neutral ❑ Low ❑ Very Low

30. Manufacturing Automation

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

31. Manufacturing Technology

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

32. Time and Motion Study

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

33. Computer Integrated Manufactuing

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

34. Electronics

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

35. Electrical

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

36. <u>Product Research and Design</u>

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

37. <u>Internship Experience</u>

☐ Very High ☐ High ☐ Neutral ☐ Low ☐ Very Low

APPENDIX C: CORE CONTENT AND SUBJECT AREA COMPETENCIES

Industrial Accounting
Strong understanding of costs involved with new technologies and the ability of justify that cost in regards to return in investment
Develop skills to relate processes to cost.
Understand balance sheets
Compare and contrast Itemized pricing vs. comparative pricing
Double entry bookkeeping

Algebra I
Solid basic development of mathematical skills with strong emphasis on the ability to work formulas without previous knowledge of the mathematical concept
Strong capability to research needed information
Perform basic computational skills.
Solve algebraic expressions (binomials & Polynomials)

Calculus I
Same as 14 above. Emphasis should be on the ability to know where to find the information and formulas, not memorization.

Chemistry I
Strong background required to develop problem solving capabilities to identify reaction, absorption, decay, fatigue in equipment, processes and products manufactured
Understand volatility
Determine chemical chains
Understand chemical reactions
Understand the Periodic Table
Know the role atomic structure plays in materials

Computer Integrated manufacturing
Ability to grasp new technologies that require computer control and integration into existing formats. Solid background in computer usage and problem solving
Specific to an area of concentration within major
Understand the philosophy of CIMS
Be able to conduct a CIMS audit
Interpret the results of the audit
Plan for CIMS integration

Computer Programming
Extremely high capabilities to adapt to changing technologies, problem solving of programs and systems
General computer use necessary for all areas, however programming may only be necessary for specific areas. Use and application of available ""boxed"" programs necessary for all areas.

Desktop Publishing
Basic knowledge.

Communication skills
Job building (training skills)
Orientation of new employees

Internship Experience
Hands-on experience in various aspects of industry to aid in deciding what areas to focus on and develop an ability to learn new technologies quickly under production or industry situations
Develops good cross training knowledge where knowledge can be transferred from one area to another
Demonstrate appropriate 'real life' work skills in a paid environment

Leadership Skills for Supervisors
Understand the technical abilities of the personnel being supervised and endeavor to fit personnel to specific operations as well as improve capabilities of each individual.
Demonstrate leadership skills in team based educational experiences
Define interpersonal skills. Handling multi cultural employees
Create a teamwork environment
Be able to motivate workers
Build Rapport
Delegate responsibility
Allow personnel the authority to complete assignments

Fundamentals of Management
Strong management capabilities geared towards technical aspects of the industry and not money management
Understanding roles of management
Organization
Planning
Control

Manufacturing Automation
Understanding the concept of cell structures and management, safety considerations and training required for individuals involved in their operation.
Specific to an area of concentration within major
Understand the strengths and weaknesses of automation
Know the capabilities of the various automated systems (agvs, overhead, towlines, roller conveyors, belt conveyors, etc.)
Be able to program plcs

Manufacturing Technology
Capable of grasping and maintaining flexibility to use, adapt or refine new technologies.
Knowledge of general manufacturing necessary for all areas
Understand the principles, theories and concepts of machining processes (lathes, mills, turning centers, milling centers, drills, surface grinders, EDM, shaping, foundry, heat treating, welding, precision measurement, etc)

Material handling
Basic knowledge of good manufacturing practices in regards to handling materials that may prove to be harmful or dangerous either in initial form or in the manufacturing process, common sense practices
Identify appropriate material handling practices.
Understand methods of materials handling
Be able to design, evaluate, and analyze material handling methods
Be able to select the proper material handling system
Match the system to the process

Material Testing
Students should be able to identify organizations that set standards for materials and materials testing, e.g., ASTM, perform commonly used tests, e.g., tensile, compression, hardness, impact, and be able to interpret the results through statistical analysis.
Basic knowledge unless the field is in Research or Engineering
Demonstrate an understanding of the nature of materials and the application of appropriate process to materials.
20,"Understand strength tests
Calculate Modulus of Elasticity, breaking strength, ultimate strength
Know Hooke's law
Know terminology Proportional limit
Be able to chart the strength of materials (ordinate & abscissa)
Select the proper test for the material application (tensile, shear, impact, compression, torsion, etc.
Analyze a stress-strain diagram

Multimedia Production
Capable of training individuals and conveying knowledge to a variety of technical skills levels using a variety of media sources
Understand principles of developing a good presentation
Develop a multimedia presentation using various media
Produce a multimedia CD or DVD

Cost Accounting
Basic knowledge with ability to recognize when to confer with more knowledgeable accountants
General accounting knowledge helpful for any area
Be able to use basic principles in developing process planning and cost related functions.
Understand methods needed for cost estimating

Quality
Students should have the ability to use statistics to establish control limits and analyze data to assure quality standards. Courses in Statistical Quality Assurance and Statistical Process Control and Design of Experiments accomplish this.

Strong ethic in quality practices develops analysis and investigative skills, problem solving, and organizational skills.
Learn quality standards and requirements relative to the chosen area of concentration within the industrial technology major.
Identify quality issues, practices and international influence of quality in the workplace.
Understand principles of quality
Interpret statistical analysis
Create an environment of quality

Product Research and Design
Development of new products and processes needed to improve efficiencies, gain market share, and enhance quality of finished products and open new opportunities for increased or new business.
Profiency in product research and design specific to area of concentration necessary in all areas.
Develop relationship between product design and manufacture
Be able to apply the appropriate design process to the design problem
Identify problems
Brainstorm
Refine ideas
Analyze and test ideas
Develop alternatives
Make decisions
Implement the design
Teamwork

Physics I
Basic background in physical characteristics of materials and equipment
Understand the physics of energy, fluid power, flow, resistance, power, and other electromechanical fundamentals
Compute simple physics problems

Physics II
Only needed if knowledge base requires engineering physics.
See Physics I

Special Processes in Manufacturing

Ability to maintain open mindedness to new process and equipment
Must show capability for analysis and adaptation
Be able to determine what a special process is in industry
Ability to maintain open mindedness to new process and equipment
Must show capability for analysis and adaptation.

Emphasis should be on analysis of results and capability to develop problem-solving solutions from the data.
Interpret and use statistical tools to provide information regarding processes and methods.
Understand Central Tendency
Interpret the Bell curve
Understand skew ness
Distinguish between 90% and 95% confidence levels

Time and Motion Study
Required to develop improved efficiency without sacrificing quality
Specific to an area of concentration within major
Understand productivity
Understand ergonomic principles
Understand the learning curve
Analyze efficient machine operation
Calculate Motion and time formulas

Verbal Communication
Capable of training individuals and conveying knowledge to a variety of technical skills levels
Proficiency in verbal communication necessary for all areas of industrial technology
Demonstrate ability to communicate in a manner appropriate to the work environment at all levels.
Be able to communicate ideas to various constituencies
Know your audience
Give Technical presentations

Written communication
Students should be able to compose a business letter in a professional style of writing and format. Students should be able to compose memoranda for internal use
Ability to develop articles and manuals that are geared to the technical level of the reader
Proficiency in written communication skills necessary for all areas of industrial of technology
Demonstrate appropriate use of written language skills
Communicate ideas via the written word
Develop training programs
Organize presentations

Technical Writing
Students should demonstrate the ability to write clearly and concisely using exacting terminology in a well-organized manner that conforms to a standard professional format.
Capable of writing highly technical papers in a way that is understandable at various levels from floor personnel to upper management
Profiency in technical writing necessary for all areas of industrial technology
Demonstrate ability to communicate in a manner appropriate to the work environment.
Know the types of business communication

Students should be able to use simple parametric and nonparametric statistics for management areas, i.e., quality assurance. methods analysis.",
Emphasis should be on analysis of results and capability to develop problem-solving solutions from the data.
Interpret and use statistical tools to provide information regarding processes and methods.
Understand Central Tendency
Interpret the Bell curve
Understand skew ness
Distinguish between 90% and 95% confidence levels

Time and Motion Study
Required to develop improved efficiency without sacrificing quality
Specific to an area of concentration within major
Understand productivity
Understand ergonomic principles
Understand the learning curve
Analyze efficient machine operation
Calculate Motion and time formulas

Verbal Communication
Capable of training individuals and conveying knowledge to a variety of technical skills levels
Proficiency in verbal communication necessary for all areas of industrial technology
Demonstrate ability to communicate in a manner appropriate to the work environment at all levels.
Be able to communicate ideas to various constituencies
Know your audience
Give Technical presentations

Written communication
Students should be able to compose a business letter in a professional style of writing and format. Students should be able to compose memoranda for internal use
Ability to develop articles and manuals that are geared to the technical level of the reader
Proficiency in written communication skills necessary for all areas of industrial of technology
Demonstrate appropriate use of written language skills
Communicate ideas via the written word
Develop training programs
Organize presentations

Technical Writing
Students should demonstrate the ability to write clearly and concisely using exacting terminology in a well-organized manner that conforms to a standard professional format.
Capable of writing highly technical papers in a way that is understandable at various levels from floor personnel to upper management
Profiency in technical writing necessary for all areas of industrial technology

Demonstrate ability to communicate in a manner appropriate to the work environment.
Know the types of business communication
Be able to write a technical report
Be able to write a laboratory report and analysis

Teamwork

Develop cross training and multiple tasking abilities so teams can work in all areas of a project.
Self-explanatory
Providing leadership in a teamwork environment. Motivating individual team members.
Develop team-building skills
Facilitate the team

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